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31 July 1981

USSR Report

ELECTRONICS AND ELECTRICAL ENGINEERING

(FOUO 8/81)



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ANTENNAS

EFFECT OF CYLINDRICAL SCREENS ON THE NOISE TEMPERATURE OF MIRROR ANTENNAS

Moscow RADIOTEKHNIKA in Russian No 2, Feb 81 (manuscript received after completion 28 Jan 80) pp 74-76

[Article by A. M. Somov]

[Text] When highly directional antennas with low-noise receivers are used, it is very important to reduce the noise temperature, an integral parameter which is a function of the directional properties of the antenna and the effective noise temperature of the environment [1].

To reduce noise temperature of antennas, it is necessary to attenuate the level of extraneous emission. We know [2] that an effective measure to reduce extraneous emission of mirror antennas is to install cylindrical screens around the perimeter of the antenna aperture (Figure 1).

The methods of calculation of antennas with such screens have been elaborated in sufficient detail. For this purpose, a method of geometric diffraction theory (GTD) is used which considers both the change in the field distribution in the aperture resulting from the presence of the screen as well as the presence of rapid oscillations in the field at the edge of the screen [3].

Figures 2 and 3 show the beam patterns (DN) of a mirror antenna with focal length $F = 45.7$ centimeters and aperture diameter $D = 122$ centimeters, calculated in the frequency range of 4 GHz in the planes E and H, respectively. The solid line denotes the antenna beam pattern without the cylindrical screen; the dotted line is with a screen 20.3 cm long; the dot and dash line is with a screen 50.8 cm long.

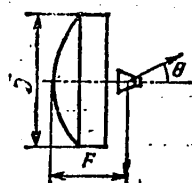


Figure 1

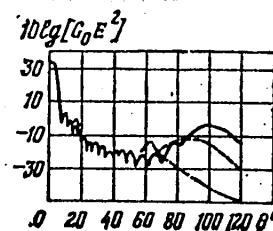


Figure 2

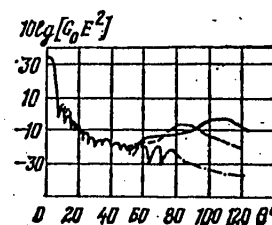


Figure 3

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For these same cases, the relationship was calculated of noise temperature of an antenna as a function of its inclination toward the horizon. The calculation was performed on the basis of a standardized portion of power of thermal noises of each sector of the beam pattern (DN). For example, a standardized portion of power equal to 0.113 without a screen in the plane H and 0.147 in the plane E; and with a 20.3 cm screen, 0.008 and 0.019, respectively, corresponded to a sector per rear hemisphere (90°-120°).

The portion of power of noises received from the rear half-space beyond this sector is small and does not affect noise temperature. In calculations, thermal losses of the feeder and thermal emission of the atmosphere reflected on the earth's surface were ignored.

The surface itself was assumed to be smooth according to Rayleigh; meteorological conditions corresponded to dry, clear weather.

The relationship of noise temperature (ShT) as a function of the angle of inclination was determined according to the formula

$$T_A = \frac{G_0}{2} \left[\int_0^\alpha T_{a_0} E^2(\theta) \sin \theta d\theta + \int_{\pi-\alpha}^\pi (T_{a_{1,1}} + T_{a_{1,r}}) E^2(\theta) \sin \theta d\theta + \int_{\pi-\alpha}^\pi T_{a_{1,r}} E^2(\theta) \sin \theta d\theta \right],$$

where G_0 is antenna gain in the direction of the primary emission maximum; $E^2(\theta)$ is the beam pattern according to power; α is the angle of inclination of the antenna to the horizon; $T_{a_0} = T_3 / \sqrt{a_a^2 b_a^2}$ is the effective noise temperature (DSHT) of the atmosphere in the sector of angles from 0 to α ; T_a is the brightness noise temperature of the atmosphere in the direction of the zenith; in this range of frequencies for dry, clear weather equals 2.9°K; $p = \arctg(T/T_{gor})$; T_{gor} is the brightness noise temperature toward the horizon. Under the same conditions $p = 0.028$;

$$a_a = \sin \alpha \cos \theta + p, \quad b_a = \sin \theta \cos \alpha;$$

$$T_{a_1} = \frac{2T_3}{\sqrt{a_a^2 - b_a^2}} \arctg \sqrt{\frac{(a_a^2 - b_a^2) \sin(\theta + \alpha)}{(a_a + b_a)^2 \sin(\theta - \alpha)}} \quad \text{для } a_a^2 > b_a^2,$$

$$T_{a_1} = \frac{T_3}{\sqrt{b_a^2 - a_a^2}} \ln \left| \frac{\sqrt{(b_a^2 - a_a^2) \sin(\theta + \alpha)} + (a_a + b_a) \sqrt{\sin(\theta - \alpha)}}{-\sqrt{(b_a^2 - a_a^2) \sin(\theta + \alpha)} + (a_a + b_a) \sqrt{\sin(\theta - \alpha)}} \right| \quad \text{для } b_a^2 > a_a^2$$

is effective noise temperature of the atmosphere in the sector of angles from α to $\pi - \alpha$.

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Effective noise temperature of the smooth surface of the earth respectively for vertically and horizontally polarized thermal emission in the sector angles from α to $\pi - \alpha$ is determined by the following expressions:

$$\begin{aligned}
 T_b &= \frac{4\epsilon \sqrt{\epsilon} T_0}{a_s^2 - b_s^2} \left\{ \sqrt{\sin^2 \theta - \sin^2 \alpha} + \frac{2(Aa_s - Bb_s)}{\sqrt{a_s^2 - b_s^2}} \times \right. \\
 &\times \left[\frac{\pi}{2} - \operatorname{arctg} \sqrt{\frac{(a_s^2 - b_s^2) \sin(\theta + \alpha)}{(a_s + b_s)^2 \sin(\theta - \alpha)}} \right], \text{ для } a_s^2 > b_s^2, \\
 T_s &= \frac{4\epsilon \sqrt{\epsilon} T_0}{a_s^2 - b_s^2} \left\{ \sqrt{\sin^2 \theta - \sin^2 \alpha} - \frac{Aa_s - Bb_s}{\sqrt{b_s^2 - a_s^2}} \times \right. \\
 &\times \ln \left| \frac{\sqrt{(b_s^2 - a_s^2) \sin(\theta + \alpha)} + (a_s + b_s) \sqrt{\sin(\theta - \alpha)}}{-\sqrt{(b_s^2 - a_s^2) \sin(\theta + \alpha)} + (a_s + b_s) \sqrt{\sin(\theta - \alpha)}} \right|, \\
 T_r &= \frac{4\sqrt{\epsilon} T_0}{a_r^2 - b_r^2} \left\{ \sqrt{\sin^2 \theta - \sin^2 \alpha} + \frac{2(Aa_r - Bb_r)}{\sqrt{a_r^2 - b_r^2}} \times \right. \\
 &\times \left[\frac{\pi}{2} - \operatorname{arctg} \sqrt{\frac{(a_r^2 - b_r^2) \sin(\theta + \alpha)}{(a_r + b_r)^2 \sin(\theta - \alpha)}} \right],
 \end{aligned}$$

while in the sector from $\pi - \alpha$ to π

$$T_{s_0} = \frac{4\epsilon \sqrt{\epsilon} T_0}{a_s^2 - b_s^2} \frac{Aa_s - Bb_s}{\sqrt{a_s^2 - b_s^2}}; \quad T_{r_0} = \frac{4\sqrt{\epsilon} T_0}{a_r^2 - b_r^2} \frac{Aa_r - Bb_r}{\sqrt{a_r^2 - b_r^2}},$$

where T_0 is the absolute physical temperature of the earth's surface; ϵ is dielectric permeability; in this frequency range for dry soil, $\epsilon = 3.5$;

$$\begin{aligned}
 a_s &= -\epsilon \sin \alpha \cos \theta + \sqrt{\epsilon}; & a_r &= -\sin \alpha \cos \theta + \sqrt{\epsilon}; & A &= -\sin \alpha \cos \theta; \\
 b_s &= -\epsilon \cos \alpha \sin \theta; & b_r &= -\cos \alpha \sin \theta; & B &= -\cos \alpha \sin \theta.
 \end{aligned}$$

Noise temperature was calculated separately for each plane E and H, wherein each time was assumed axial symmetry of the beam pattern. The practical difference of the beam pattern in these planes was considered by averaging the results of calculation in terms of the main planes. Furthermore, in each of the planes was considered two cases of polarization of thermal emission: vertical and horizontal, after which the calculation results were also averaged.

In this way, the calculated noise temperature is valid for an antenna operating with circular polarization. The relationship of theoretical noise temperature versus the angle of inclination of the antenna to the horizon is cited in Figure 4 (solid line: no screen, dotted line: screen 20.3 cm long; dotted and dashed line screen 50.8 cm long).

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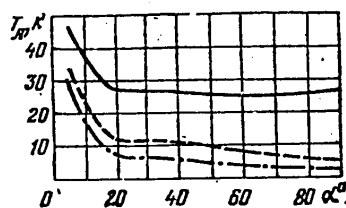


Figure 4

As the results of analysis showed, cylindrical screens in the aperture of mirror antennas are effective means for reducing noise temperature.

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MULTICHANNEL LIGHT MODULATORS FOR OPTICAL SIGNAL PROCESSING SYSTEMS OF
ANTENNA ARRAYS

Moscow RADIOTEKHNIKA in Russian No 2, Feb 81 (manuscript received 27 May 80)
pp 6-14

[Article by L. D. Bakhrakh, D. B. Ovezov (deceased), S. G. Rudneva and
V. B. Shverin-Kashin]

[Text] Introduction

Optical radio signal processing systems have become very popular in the last decade. The use of coherent light as an information carrier enables the performance of parallel processing of information and its transmission, with great speed. These properties of coherent systems govern the outlook for their use to process the signals of antenna arrays, in order to resolve such problems as parallel surveying of space [1], correction of errors due to deformation of the profile of mirror antennas (problem of focal synthesis) [2, 3], processing of signals of circular arrays [4, 5], some problems of antenna measuring technique [6] and processing of signals in stations which have an artificial aperture [7].

The basic component of any optical processing system is the information input and light modulator device. There are many different types of modulators, which may be explained by the large number of physical effects that enable us to alter amplitude and phase of collimated coherent light flux; and also by the large number of media which can be used to implement certain effects. Various types of modulators are also used in signal processing systems of antenna arrays. The resolution of some problems requires a system with real-time signal processing (parallel surveying, focal synthesis). The modulator must perform operative input of information, thus it employs a medium with lag-free variation of parameters (coefficient of transmittance, index of refraction, thickness, etc.). In other cases the signal may be subjected to intermediate recording and media are employed which have memory (recording on photographic film, thermoplastic recording), e.g., signal processing in stations having an artificial aperture, problems of measuring technique. In this way, specific requirements imposed on a data input device depend on the nature of the problem being tackled. In addition to the requirements governed by the specifics of individual problems, however, there are general requirements which are basic in nature, that are related equally to all modulators utilized to process antenna array signals. These requirements will be examined below.

Basic Requirements Imposed on Modulators Used in Antenna Array Signal Processing Systems

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A specific feature of antenna array signal processing systems is their multichanneling. A modulator with a number of channels equal (sometimes more) to N corresponds to an antenna consisting of N elements. According to the nature of the problem to be tackled, the number N may vary widely: thus, in the problem of focal synthesis the number of channels is comparatively small--as a rule 10-20; in parallel scanning it constitutes several tens or hundreds; in artificial aperture systems it may be over a thousand. Naturally problems may arise linked with the multichanneling in certain instances, as regards placing a modulator in the aperture of the optical processing device which is limited in size.

An extremely important aspect of light modulators used for service in antenna array signal processing systems is the complex nature of distribution of the SHF field in antenna elements. Signals of individual elements differ in amplitude and phase. The light modulator must transmit a complex field from the antenna to the coherent light flux. The law of amplitude-phase distribution in light flux passing through a modulator must satisfy the law of field distribution in the antenna, or else the signal processing job can not be tackled. We shall detail this requirement here.

If each element of an antenna array separately contained information about the amplitudes and phases, then the problem could be resolved by direct effect individually on light amplitude and phase. It would then be sufficient to set two layers in the path of the coherent light flux, one of which could alter the degree of transmittance (affect light amplitude), and the other which could alter its thickness or coefficient of refraction (affect its phases). But it is extremely difficult to obtain separate information about amplitudes and phases of signals in discrete antenna array elements, considering their two directionality values: it would mean solving the signal-to-noise problem in each channel. Furthermore, the use of media with two variables to modulate light and solve problems of signal processing of multiple-element antenna arrays would be inefficient. Transmission of information into light flux about amplitude-phase distribution of the SHF field in an antenna array is accomplished by effects on any (according to the material) single parameter of the modulator's medium. For this purpose, in each processing channel corresponding to an individual emitter, the signal must be specially processed to obtain control voltages.

Control voltages can be obtained by linear or non-linear processing of signals in individual channels of the processor. Linear processing signifies processing where the SHF signal is amplified and subjected to frequency transformation. These transformations are linear in that they retain the amplitude and phase relationships between the signals of individual channels. A change in the variable parameter of the modulator medium occurs with the frequency of the modulating voltage. Let us observe that in linear processing of signals, frequency transformation is not an essential prerequisite. Indeed, in the most developed modulators today, the frequency of the control voltages is much lower than the frequency of signals received by the antenna. A trend has recently appeared toward increasing the frequency of control voltages up to and including the frequency of the initial signals. According to how the parameter of the medium is changed, there is modulation of the phase and amplitude of the light flux passing through the modulator. In this way, in linear signal processing the transmission of information into the light flux is performed by amplitude or phase time modulation and may, for instance, be effected using ultrasonic or optoelectronic modulators.

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Let us consider nonlinear preliminary processing of signals. In contrast to linear processing, the control voltage in this case affects the medium of the modulator and is proportional to the intensity of the radiosignal and the signal entering the modulator, but has no frequency change. To preserve information about the amplitude and phase, an external reference field should be used and thereby obtain an interferogram (hologram) of the field; or a phase detector used to detect one of the quadrature components, which is also a hologram. Therefore, in nonlinear preliminary signal processing, information about the field in the antenna array is transmitted into the light range not with the aid of time modulation, but through amplitude and phase distributions.

On the Role of a Three-Dimensional Carrier Frequency

When control voltages of linear preliminary signal processing are obtained, the light flux is time modulated; in nonlinear processing, amplitude or phase distributions of the light flux are produced in the modulator. In both cases one variable parameter of the light flux is utilized. In this context, there is a certain equivalency of such modulators from the standpoint of information possibilities and uniqueness of depicting the SHF field in the light range.

Let us express the field distribution in a linear antenna array whose elements are situated along axis x by the function

$$f_p(x, t) = A_p(x) \sin[\omega_p t + \varphi_p(x)], \quad (1)$$

where $A_p(x)$ and $\varphi_p(x)$ are the distribution of amplitudes and phases of radiosignals; ω_p is angular frequency of the radiosignal.

After the appropriate linear preliminary transformations of the signals in (1) and as a result of amplitude modulation at the modulator output, the following light field will be observed

$$f_{ls} = \sin \omega t \{1 + m_a(x) \sin[\Omega t + \varphi_p(x)]\} = \sin \omega t + \frac{m_a(x)}{2} \cos[(\omega - \Omega)t - \varphi_p(x)] - \frac{m_a(x)}{2} \cos[(\omega + \Omega)t + \varphi_p(x)], \quad (2)$$

where $m_a(x)$ is the index of amplitude modulation proportional to the amplitude of $A_p(x)$ of the signal in the antenna; ω is the angular frequency of the collimated light flux of coherent light; Ω is the angular frequency of the modulating voltage.

Light field at the modulator output in phase modulation is expressed in a similar fashion:

$$f_{ls} = \sin[\omega t + m_\phi(x) \sin[\Omega t + \varphi_p(x)]] = J_0[m_\phi(x)] \sin \omega t - J_1[m_\phi(x)] \sin[(\omega - \Omega)t - \varphi_p(x)] + J_1[m_\phi(x)] \sin[(\omega + \Omega)t + \varphi_p(x)],$$

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where $m_\phi(x)$ is the index of phase modulation proportional to the amplitude of the signal in the antenna; $J_0(m_\phi)$ and $J_1(m_\phi)$ are Bessel functions of the zero and first orders.

$$f_{cs} = \sin \omega t - 1 \frac{m_\phi(x)}{2} \sin [(\omega - \Omega)t - \varphi_p(x)] + 1 \frac{m_\phi(x)}{2} \sin [(\omega + \Omega)t + \varphi_p(x)]. \quad (4)$$

As can be seen from a comparison of (1) and (4), the useful information is contained in the side frequencies in both cases. The phases of the SHF signals is reproduced to within the sign in the light fields of the side frequencies, the amplitudes of the SHF field are transmitted by the amplitudes of the side frequencies. In phase modulation, amplitude-phase relationships between the channels are preserved as long as the index of phase modulation is small.

In nonlinear preliminary signal processing, the control voltage can be described by the function

$$f_{yp}(x) = b + a_p(x) \sin \varphi_p(x), \quad (5)$$

where b is the level of the reference signal.

As a result of the impact of control voltages on the amplitude of the light flux at the modulator output we find that

$$f_{as} = b \sin \omega t + \frac{a_p(x)}{2} \cos [\omega t - \varphi_p(x)] - \frac{a_p(x)}{2} \cos [\omega t + \varphi_p(x)]. \quad (6)$$

If the control voltage affects the phase of light, the field is described by the expression

$$\begin{aligned} f_{cs} = \sin [\omega t + a_p(x) \sin \varphi_p(x)] = \sin(\omega t) \cos [a_p(x) \sin \varphi_p(x)] + \\ + \cos(\omega t) \sin [a_p(x) \sin \varphi_p(x)] \approx J_0[a_p(x)] \sin \omega t - \\ - J_1[a_p(x)] \sin [\omega t - \varphi_p(x)] + J_1[a_p(x)] \sin [\omega t + \varphi_p(x)]. \end{aligned} \quad (7)$$

In equation (7) the constant component of phase, proportional to the level of the reference signal b , is omitted. In (6) and (7), as in time modulation, there are three light fields at the modulator output: the field of the constant component and two fields containing the SHF signal characteristics. This is basically due to the fact that any kind of modulated field can not be described by a single component.

Leaving aside the question of interference due to the constant component of light flux for a while, let us mention the ambiguity of depiction of the HF field by light fluxes. This ambiguity is inadmissible in all problems involved with the processing of antenna array signals. In problems of parallel scanning, owing to the presence of complex-coupled fields, a loss of the sign of angular coordinate of the source occurs; the same may be said of an artificial aperture station. In focal synthesis problems, the presence of these fields precludes the possibility of matched reception. Under these circumstances, system efficiency

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can only be preserved in special cases where there exists additional information about the sign of the angular coordinate or there is a guarantee that the sources are located on the same side of the line normal. The latter condition is made if the array elements have sufficient directionality and are turned to ensure reception only on the left or only on the right of the line normal.

The above makes it clear that in the overwhelming majority of cases, special measures must be taken to eliminate noise due to the simultaneous presence of complex-coupled light fields in the input aperture of the optical device. The situation can be rescued by three-dimensional filtration of signals, i.e., by deflecting fluxes corresponding to these fields. The linear component ω_x should be inserted into the independent variable of the phase multiplier of the control voltage of (5). Then expressions (6) and (7) will become, accordingly:

$$f_{3\text{cs}} = b \sin \omega t + \frac{a_p(x)}{2} \cos[\omega t - \varphi_p(x) - \omega_x x] - \frac{a_p(x)}{2} \cos[\omega t + \varphi_p(x) + \omega_x x]; \quad (8)$$

$$f_{4\text{cs}} \approx J_0[a_p(x)] \sin \omega t - J_1[a_p(x)] \sin[\omega t - \varphi_p(x) - \omega_x x] + J_1[a_p(x)] \sin[\omega t + \varphi_p(x) + \omega_x x]. \quad (9)$$

Fluxes corresponding to the three light fields at the light modulator output according to (8) and (9) are now propagated in directions characterized by the angles:

$$\theta_0 = 0; \theta_1 = \frac{\omega_x}{k}; \theta_{-1} = -\frac{\omega_x}{k},$$

where k is the wave number. The parameter ω_x may be viewed as a three-dimensional carrier frequency [8]. With an increase in ω_x , separation (filtration) of the sectors of unique correspondence of light fields and SHF field increases. Introduction of the three-dimensional carrier may require an increase in the number of channels of the modulator as compared to the number of array elements. The relationship between the period of the three-dimensional carrier and the number of variable elements (channels) of the modulator is a function of the nature of the problem being tackled.

Let us analyze the relationship between the period of the three-dimensional carrier frequency T_{pr} and the distance between the modulator channels d_m , assuming that the three-dimensional carrier and the modulator channels are distributed along the x axis. Based on the principles of nonscalar simulation, a section in the plane of indication of the optical system (this is usually the focal plane of the transforming lens) can be determined, which is situated along the x_ϕ axis and corresponds to the scanning sector of the antenna array.

In the commonest case the scanning sector is measured through an angle of 90° with respect to the line normal to the array. The sector which images the sector in the optical system is determined by the ratio λ/d_m and the focal

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length of the lens f . This sector is periodically repeated within the wide diffraction spot which corresponds to one channel; this is the result of nonscalar simulation [9].

In Figure 1, any fragment $x_{\phi_1}, x_{\phi_2}; x_{\phi_2}, x_{\phi_2}$, etc. depicts the antenna scanning sector. The length of this fragment is

$$x_{\phi_1}, x_{\phi_2} = 2 \frac{\lambda}{d_m} f. \quad (10)$$

In the absence of a three-dimensional carrier, one diffraction spot $J(x_{\phi})$ in the center of each fragment corresponds to the signal entering from the source situated in a direction normal to the antenna: the width of the spot is controlled by the overall length of the modulator. If the signal from the source enters at some angle ϕ to the line normal, each fragment will show two diffraction spots $J(x_{\phi})$ and $J^*(x_{\phi})$ in conformity with the presence of two complex-coupled light fields in the modulator. Both spots are displaced (Figure 2) from the center of the fragment symmetrically by a distance equal to

$$\Delta x_{\phi} = \frac{\lambda}{d_m} f \sin \varphi. \quad (11)$$

Let us consider the same modulator with the introduction of a three-dimensional carrier, assuming that its period

$$T_{op} > d_m.$$

To satisfy this condition, signals being fed into the modulator channels must first pass through a delay line or phase inverter and acquire additional phase shifts which are linear functions of the channel number. Now, in conformity with the steepness of the linear phase incursion, the spot corresponding to a signal from the source situated in the direction of the line normal, is displaced in each complex-coupled field (Figure 3) by an amount

$$\Delta x_{\phi}(\Delta\psi) = \pm \frac{\lambda}{d_m} f \frac{\Delta\psi}{\pi}, \quad (12)$$

where $\Delta\psi$ denotes the phase change between two adjacent channels introduced with the aid of the phase inverter, delay lines or any other method.

The quantity $\Delta\psi$ determines the period of the three-dimensional carrier frequency

$$T_{op} = \frac{2\pi}{\Delta\psi} d_m. \quad (13)$$

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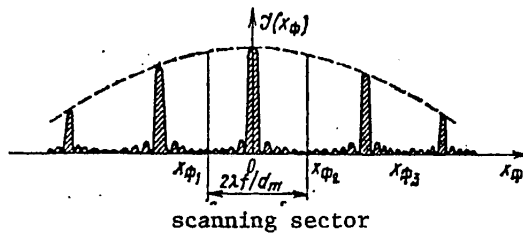


Figure 1

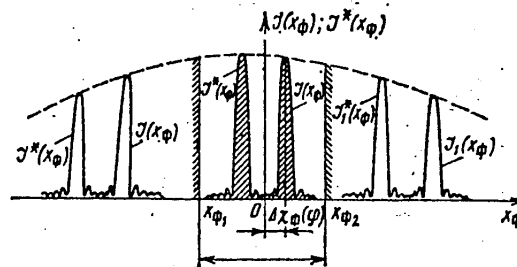


Figure 2

Each diffraction spot in Figure 3 corresponds to a signal passing through the array along a line normal; thus the position of these spots determines the center of scanning in each of the two light fields. With an inclined incidence of the signal onto the array, the diffraction spot moves away from the center of the sector accordingly in some direction through a fragment

$$\Delta x_{\phi}(\varphi) = \frac{\lambda}{d_m} f \sin \varphi. \quad (14)$$

It is difficult to show that, for sectors depicting the scanning sector in two complex-coupled fields not to overlap (Figure 4), the size of the phase jump of signals entering adjacent channels of the modulator must be limited to values lying within the limits of 0 to π radians. This condition may be satisfied by an appropriate narrowing and orientation of the beam pattern of the emitting array at an angle. The direction of their zero emission must satisfy the conditions:

$$\sin \varphi_1 = -\frac{\Delta \psi}{k_p D_a}; \quad \sin \varphi_2 = \frac{\pi - \Delta \psi}{k_p D_a}, \quad (15)$$

where $k_p = 2 / \lambda_p$ is the wave number; D_a is the distance between array elements.

Let us note that the separation of sectors in complex-coupled light fields can be produced without rotating emitters, if their beam patterns are narrowed correctly (Figure 5).

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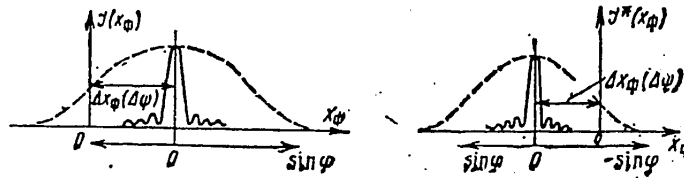


Figure 3

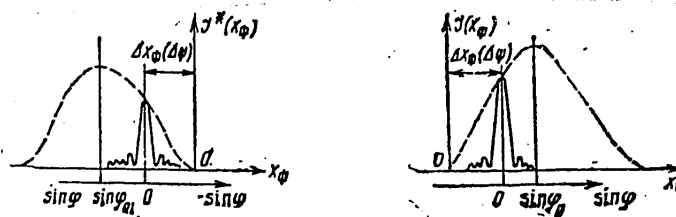


Figure 4

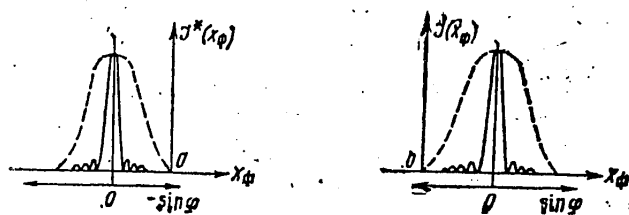


Figure 5

Thus, it is theoretically possible to separate sections of unique correspondence to the scanning sector in the optical system by introducing a three-dimensional carrier with a period of $T_{pr} > d_m$, with rotation and adequate

narrowing of the beam patterns of the array emitters. As illustrated by an artificial aperture station, it can be shown to be possible to implement this reception in practice. In stations of side scanning, signal processing involves the use of a natural phase incursion from "channel" to "channel" due to the Doppler component. For this purpose, the pattern of the on-board antenna (i.e., the pattern of the individual emitter) is appropriately rotated within the array. The period of the three-dimensional carrier may be much greater than d_m here. The necessary narrowing of the pattern is easy to implement, since the size of the on-board antenna can be made several times greater than the distance between elements.

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As concerns other problems: parallel scanning, focal synthesis, processing signals of circular antenna arrays, practical realization of the requirements necessary to separate sectors in an optical system is encumbered by many technical problems. The use of a three-dimensional carrier having a rather large period ($T_{pr} > d_m$) would require the use of narrow beam patterns of the emitters $\theta \leq 90^\circ$. To shape such a pattern the aperture of the individual element would have to be

$$D_s \geq 1.5\lambda_p, \quad (16)$$

where λ_p is the radiosignal wavelength. The period of installation of emitters in contrast to a synthesized antenna should be of the same magnitude D_a . In this connection, a problem of polyvalency arises which results from the presence of interference lobes in the scanning sector. The array factor and the width of the pattern of the elements is in a relationship where the unique scanning can be guaranteed within the sector not to exceed $\pm \arcsin \frac{\lambda_p}{2D_a} \approx \pm 20^\circ$. In prob-

lems of focal synthesis and signal processing of circular arrays, the emitter period should be on the order of $\lambda_p/2$; it is thus impossible to shape the emitter beam pattern in conformity with requirements [15].

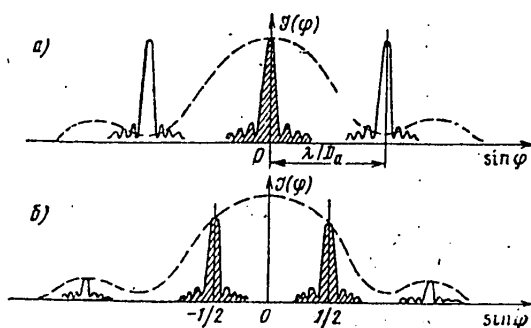


Figure 6

An ideal example of using a three-dimensional carrier having a period exceeding the interval between channels in a modulator is a transparency with the recording of the signals of a side scanning station. In problems of processing signals of antenna arrays in real time, the use of such a modulator is limited to a system of parallel scanning with a sector not to exceed 40° . In this case the problem can be tackled with the use of an optoelectronic modulator.

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Let us consider the use of a three-dimensional carrier in a modulator, with a small period ($T_{pr} \ll d_m$). In this case, the orientation of the carrier is possible along an axis in which are situated the channels of the modulator, and in the direction perpendicular to it. Practical realization of a modulator with a small period of carrier depends on the nature of the preliminary signal processing and the type of modulating medium.

Let us consider optoelectronic modulators. If nonlinear processing and electron beam recording are used in the system, the three-dimensional frequency can be obtained as a result of linear change in the frequency of the reference field. Three-dimensional modulators of this type are based on the longitudinal optoelectronic effect. The electron beam governs the three-dimensional distribution of potential on the surface of the optoelectronic modulator. The passing light flux is modulated in conformity with the recorded potential relief. The situation is much more complicated with optoelectronic modulators operating in real time, which use linear processing of the signal and time modulation. To obtain a three-dimensional carrier with small period here, it is necessary to greatly expand the number of channels of the modulator as compared to the number of array elements; this, in turn, requires the use of dividers which can be used to distribute the signal of each array element to several modulator channels. In the sector between the divider and the modulator are introduced phase shifts; using them, a three-dimensional carrier frequency is established. In this way, in optoelectronic modulators operating in real time, the production of three-dimensional frequency runs up against real problems.

In ultrasonic modulators, the three-dimensional carrier is realized more naturally: it is a propagating ultrasonic wave. In these modulators, a very high degree of three-dimensional filtration of light fields is achieved, and the angle of deflection of light flux equals $\theta = \pm \frac{\lambda}{\Lambda}$ (Λ is the wavelength of

ultrasound). In most antenna problems solved using optical devices, high separation of sectors of uniqueness of depiction is necessary. Therefore, when evaluating the basic indicators of optoelectronic and acoustooptical modulators, this notion is decisive. In this connection, it is advisable to examine several basic properties of acoustooptical modulators.

Several Properties of Acoustooptical Modulators

Let us consider the most essential properties of ultrasonic modulators. In optical signal processing devices of multichannel antenna systems, it is very important to obtain a very high isolation between modulator channels (up to 20 dB), to insure nearly complete identity of channels, processing of broad-band signals and long signals. Let us establish a connection between these requirements and the modulator parameters which correspond to them.

The question connected with isolation between channels becomes especially acute as the width of piezo transducers is reduced (and their installation spacing) in a multichannel modulator, since with the decrease in transverse size of

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of the piezo transducers the so-called piston zone is reduced. Let us note that the linearity of modulation conditions, i.e., transmissions in the optical information range about amplitude-phase distribution of the SHF field in elements of the antenna, can be achieved while operating in the piston zone of piezo transducers of an acoustooptical modulator. The solution of this problem is found by using a waveguide type modulator design, i.e., by using separate soundguides for each soundguide channel. To manufacture waveguide modulators, materials are required which allow mechanical and optical treatment nad have enhanced hardness. Furthermore, let us note that with a width of piezo transducers less than one millimeter, the manufacture of a waveguide type modulator is a complicated technological job. In some anisotropic crystals, the required values of isolation between channels are achieved by selecting completely defined directions of propagation of the acoustic wave. Thus, in paratellurite with a direction (110) and diffraction of light on a longitudinal ultrasonic wave, monoblock multichannel modulators can be realized using almost any technically feasible width of piezo transducers. Crystals of lead molybdenate can be used in the same manner.

Satisfaction of the requirements of linear reproduction of amplitude and phase relationships, retention of the dynamic range and signal-to-noise ratio is connected with the selection of a material having high value of the coefficient of diffraction activity M , [10]. High diffraction activity enables us to excite ultrasonic waves with low values of signal input power. Let us mention that the increased diffraction activity is promoted by the use of diffraction conditions in the modulator, close to Bragg diffraction. It is especially important to shift to Bragg diffraction in multichannel modulators used to correct distortion in optical range antennas [11]. It should be added that to retain the desired signal-to-noise ratio and dynamic range, inherent light noises of the modulator arising from the background of the constant component of light flux should be reduced to the minimum. The background can be reduced by increasing the angle between the diffracted flux and the flux of constant component, which is achieved by increasing the ultrasonic frequency and reducing the rate of its propagation in the medium. Of all currently known materials, paratellurite has the lowest rate of propagation of ultrasound. In this crystal there is a direction where sound propagates at a velocity of 0.6×10^3 meters per second. Calomel crystals also have parameters close to paratellurite. Furthermore, an extremely effective method of suppressing the constant component is the use of anisotropic diffraction with rotation of the polarization plane in the diffracted light beam.

The requirement of processing broad-band signals is solved mainly by an appropriate increase in the mean frequency of ultrasound. To process signals of great length, soundguide media should be used which have a low rate of propagation on the one hand, and low attenuation of ultrasound on the other. To these requirements we should add the requirements common to all kinds of light modulators: transmittance in the proper range of light wavelengths.

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The functional possibilities of coherent optical systems for processing signals of antenna arrays is largely determined by the information input device. The use of ultrasonic modulators enables the maximum utilization of the possibility of optical systems in tackling antenna problems and some related questions.

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COMMUNICATIONS, COMMUNICATION EQUIPMENT, RECEIVERS
AND TRANSMITTERS, NETWORKS, RADIO PHYSICS, DATA
TRANSMISSION AND PROCESSING, INFORMATION THEORY

UDC 621.391.82:621.396.6

DETERMINING PROBABILITY OF INTERMODULATORY INTERFERENCE IN A RECEIVER

Moscow RADIOTEKHNIKA in Russian No 2, Feb 81 (manuscript received after completion 25 Jun 80) pp 70-73

[Article by V. I. Voloshin]

[Text] In evaluating the electromagnetic compatibility (EMS) of radio devices (RS) of communications complexes, it is necessary to determine the probability of intermodulatory interference in receivers (IP) which occurs when several RC complexes are transmitting at the same time [1-3]. Because complexes usually use RS of various ranges and IP are generated by intermodulatory emissions (II) of various orders, in contrast to [2] we will not impose constraints on the ranges of operating frequencies of RS and orders of II. Furthermore, we will limit our examination to the frequency-energy conditions of IP vulnerability of a receiver for complexes of closely situated narrow-band RS, power of extraneous emissions and the sensitivity of side channels of which are extremely attenuated as compared to the output of basic emissions and sensitivities throughout the primary channels. It can then be considered that IP occur only as a result of II entering the primary reception channel, having been formed during interaction of primary emissions of the transmitters in their output circuits [4]. When necessary, incidence of II can enter other channels of reception.

The frequencies of II arising in simultaneous transmission of several (m) RS equal

$$f_{a1k...l} = |lf_a + kf_b + \dots + lf_c|, \quad (1)$$

where f_a, f_b, \dots, f_c are frequencies of the $a^{\text{th}}, b^{\text{th}}, \dots, c^{\text{th}}$ RS transmitting; $i = 1, 2, \dots, k, l = \pm 1, \pm 2, \dots$

Let us designate the minimal and maximal frequencies of the range of the i^{th} RS accordingly of f_{in} and f_{iv} and let us designate

$$\Delta f_i = f_{iv} - f_{in}, \quad \bar{f}_i = \frac{1}{2}(f_{in} + f_{iv}),$$

$$f'_{a1k...l} = lf_a + kf_b + \dots + lf_c, \quad \bar{f}'_{a1k...l} = l\bar{f}_a + k\bar{f}_b + \dots + l\bar{f}_c \quad (2)$$

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To determine the probability density of II frequency $f_{u1k...1}$, let us use relationships for the probability density of functions of random values [5] and consider that RS frequencies of complexes, when evaluating EMS, can be considered evenly distributed random independent quantities [6]. Based on (1) and (2), we find that

$$W_{u1k...1}(f) = W'_{u1k...1}(f) + W'_{u1k...1}(-f), f \geq 0, \quad (3)$$

where for the case of simultaneous transmission of two RS ($m = 2$)

$$W'_{u1k}(f) = \begin{cases} \frac{f - \epsilon_1}{l|k|\Delta f_a \Delta f_b} & \text{при } \epsilon_1 \leq f \leq \epsilon_2, \\ \frac{1}{\max(l\Delta f_a, |k|\Delta f_b)} & \text{при } \epsilon_1 \leq f \leq \bar{f}'_{u1k}, \end{cases} \quad (4)$$

$$\epsilon_1 = \bar{f}'_{u1k} - \frac{1}{2}(l\Delta f_a + |k|\Delta f_b), \quad \epsilon_2 = \bar{f}'_{u1k} - \frac{1}{2}|l\Delta f_a - |k|\Delta f_b|. \quad (5)$$

With simultaneous transmission of three RS ($m = 3$), the functions $W'_{u1k1}(f)$ are determined by relationships cited in the table for a series of frequently encountered cases. One of these cases under the least common conditions is examined in [7]. In the tabular formulas

$$\epsilon_j = \bar{f}'_{u1k1} - \frac{1}{2}\eta_j, \quad j = \overline{1,4}; \quad (6)$$

$\eta_1 - \eta_4$ are the set of numbers $\xi_1 - \xi_4$ arranged in decreasing order:

$$\begin{aligned} \xi_1 &= l\Delta f_a + |k|\Delta f_b + |l|\Delta f_c, \quad \xi_2 = |l\Delta f_a + |k|\Delta f_b - |l|\Delta f_c|, \\ \xi_3 &= |l\Delta f_a - |k|\Delta f_b + |l|\Delta f_c|, \quad \xi_4 = |l\Delta f_a - |k|\Delta f_b - |l|\Delta f_c|. \end{aligned} \quad (7)$$

Relationships for $W'_{u1k...1}(f)$ are cited for $f \leq \bar{f}'_{u1k...1}$, because these functions are symmetrical with respect to $\bar{f}'_{u1k...1}$.

At $m \geq 4$, the probability density of $W'_{u1k...1}(f)$ can be determined by methods presented in [8].

Frequency-energy conditions of the presence of IP have the form:

$$|f_{u1k...1} - f_j| \leq \Delta F_{j1k...1}, \quad l + |k| + \dots + |l| \leq q_{\max}. \quad (8)$$

Here f_j is the tuning frequency of the j^{th} receiver; $\Delta F_{j1k...1}$ and q_{\max} is the maximum detuning between II frequency and receiver tuning frequency and the maximum order of II at which the action of IP appears (in intolerable limits reception quality deteriorates in the given sense). Since output circuits of transmitters are generally rather wide-banded and the levels of attenuation of II become normal only for a specific relationships of frequencies of transmitters f_a, f_b, \dots, f_c [9, 10], the relationship of $\Delta F_{j1k...1}$

Table 1

Условия приме- нимости формул или определения $W_a, k_l(f)$	$ \Delta f_a + k \Delta f_b < f \Delta f_c$ или $ f \Delta f_c < \min(\Delta f_a , k \Delta f_b)$ $ f \Delta f_c < \Delta f_a - k \Delta f_b $	$\min(\Delta f_a , k \Delta f_b) <$ $< f \Delta f_c < \max(\Delta f_a , k \Delta f_b)$ $ \Delta f_a - k \Delta f_b < f \Delta f_c$	$ \Delta f_a = k \Delta f_b$	
			$ f \Delta f_c < \Delta f_a $ $v_1 = v_2 = v_3$	$ \Delta f_a < f \Delta f_c < 2 \Delta f_a $ $v_1 = v_2 = v_3$
$v_1 \leq f \leq v_2$ или $v_1 \leq f \leq v_3$			$\frac{1}{2} \frac{(f - v_1)^2}{ k \Delta f_a \Delta f_b \Delta f_c }$	
$v_2 \leq f \leq v_3$ или $v_2 \leq f \leq v_1$			$\left[f - \frac{1}{2}(v_1 + v_2) \right] \frac{\min(\Delta f_a , k \Delta f_b , f \Delta f_c)}{ k \Delta f_a \Delta f_b \Delta f_c }$	
$v_3 \leq f \leq v_1$ или $v_3 \leq f \leq v_2$	$\frac{\max(\Delta f_a , k \Delta f_b , f \Delta f_c)}{1 - \frac{1}{2} \frac{(f - v_1)^2}{ k \Delta f_a \Delta f_b \Delta f_c }}$	$\frac{\max(\Delta f_a , k \Delta f_b)}{1 - \frac{1}{2} \frac{(f - v_1 - v_2)^2}{ k \Delta f_a \Delta f_b \Delta f_c }}$		$\frac{1}{ k \Delta f_c } - \frac{1}{2} \frac{(f - v_1 - v_2)^2}{ k \Delta f_a \Delta f_b \Delta f_c }$
$v_1 \leq f \leq v_2$ или $v_3 \leq f \leq v_2$	$\frac{\max(\Delta f_a , k \Delta f_b , f \Delta f_c)}{1 - \frac{1}{2} \frac{(f - v_2)^2}{ k \Delta f_a \Delta f_b \Delta f_c }}$	$\frac{1}{ k \Delta f_c } - \frac{1}{2} \frac{(f - v_1)^2 + (f - v_2 - v_3)^2}{ k \Delta f_a \Delta f_b \Delta f_c }$		$\frac{1}{ k \Delta f_c } - \frac{1}{2} \frac{(f - v_1)^2 + (f - v_2 - v_3)^2}{ k \Delta f_a \Delta f_b \Delta f_c }$

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as a function of f_a, f_b, \dots, f_c are not taken into account during analysis.

The probability of receiver vulnerability while operating in the frequency range from f_{jn} to f_{jv} by specific II $P_{j, ik...l}$, is equal to the probability of satisfaction of condition (8). For detection of $P_{jik...l}$, let us use relationships to determine the probability density of the difference of two random quantities [5] and let us consider the condition of narrow-bandedness of IP $\Delta F_{jik...l} \ll f_{jn}$. As a result we find that

$$P_{j, ik...l} = 2 \frac{\Delta F_{j, ik...l}}{\Delta f_j} \int_{f_{jn}}^{f_{jv}} W_{u, ik...l}(f) df. \quad (9)$$

When $m \geq 4$, $P_{j, ik...l}$ is expressed by the tabular functions [8].

Analysis shows that when the IP narrow-bandedness condition is satisfied, the probability of simultaneous vulnerability of a receiver by two or more II generated by specific transmitting RS is much less than the probability of vulnerability by one of the II. Consequently, the probability of vulnerability of a receiver by IP arising in simultaneous transmission of m RS is approximately equal to

$$P_{u, j, ab...c} \approx \sum_{l, k, \dots, i} P_{j, ik...l} \quad l + |k| + \dots + |l| \leq q_{max} \quad (10)$$

For cases where $F_{jik...l}$ depends only on the order of II q or on the type of receiver, i.e., $\Delta F_{j, ik...l} = \Delta F_{j, q}$ or $\Delta F_{j, ik...l} = \Delta F_j$, we find from (9) and (10) that

$$P_{u, j, ab...c} = \frac{2}{\Delta f_j} \sum_{q=2}^{q_{max}} \Delta F_{j, q} \int_{f_{jn}}^{f_{jv}} W_{u, ab...c}^{(q)}(f) df, \quad (11)$$

$$P_{u, j, ab...c} = 2 \frac{\Delta F_j}{\Delta f_j} \int_{f_{jn}}^{f_{jv}} W_{u, ab...c}(f) df, \quad (12)$$

where

$$W_{u, ab...c}^{(q)}(f) = \sum_{l, k, \dots, i} W_{u, ik...l}(f), \quad l + |k| + \dots + |l| = q, \quad (13)$$

$$W_{u, ab...c}(f) = \sum_{q=2}^{q_{max}} W_{u, ab...c}^{(q)}(f) \quad (14)$$

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are functions which can be obtained by graphic summation of the probability densities of $W_{uik...1}(f)$. These functions are not probability densities and are introduced for the convenience of recording and computation.

From the results obtained in [11], it follows that during operation of RS at discrete frequencies, multiples of the grid spacing, the following should be substituted in (12) instead of ΔF_j

$$\Delta F'_j = \Delta F_j + \frac{1}{2} (\Delta F_{wj}, \Delta F_{wa}, \Delta F_{wb}, \dots, \Delta F_{wc}); \quad (15)$$

where ΔF_{mi} is the spacing of the discrete grid of frequencies of the i^{th} RS (x, y, z, \dots, u) is the greatest common divisor of the numbers x, y, z, \dots, u . Usually, $\Delta F_j \approx \Delta F'_j$.

When necessary to consider time characteristics of IP, the value of $P_{uj \text{ ab} \dots c}$ obtained should be multiplied by the probability value of simultaneous operation of the RS generating the IP [2].

The results of a test run by the method of statistical simulation on computer prove the validity of the assumptions made and the accuracy of the proposed methods which are sufficient for practical purposes. The error in determining the magnitude of $P_{uj, \text{ab} \dots c}$ as a rule does not exceed three percent. If we have data on the magnitude of $P_{uj, \text{ab} \dots c}$, it is possible to estimate the EMS of an RS complex based on IP [1, 3].

In concluding, the author wishes to thank L. I. Sen'ko and Ye. V. Zadedyurin for aid in evaluating the accuracy of the methods.

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PUBLICATIONS

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ANALOG-DIGITAL CONVERTERS (DESIGNING ELECTRONIC EQUIPMENT USING INTEGRATED MICROCIRCUITS)

Moscow ANALOGO-TSIFROVYYE PREOBRAZOVATELI (PROYEKTIROVANIYE RADIOELEKTRONNOY APPARATURY NA INTEGRAL'NYKH MIKROSKHEMAKH) in Russian 1980 (signed to press 5 Feb 80) pp 2, 276-8

[Annotation and table of contents from book "Analog-Digital Converters (Designing Electronic Equipment Using Integrated Microcircuits)", by German Dmitriyevich Bakhtiarov, Vadim Vladimirovich Malinin and Vladimir Petrovich Shkolin, Izdatel'stvo "Sovetskoye radio", 20,000 copies, 280 pages]

[Text]

Annotation

Design features of analog-digital converters (ATsP) with integrated microcircuits are examined, and the methodology for calculating their precision characteristics and speed is given. Explained are the design principles and state of the component base of modern ATsP: digital-analog converters, reference voltage sources, analog switches, commutators, comparators, and sampling and storage devices. Considerable attention is devoted to estimating dynamic error and methods of reducing it. Data on fully integrated ATsP and on the design principles of converters using micro-processors are generalized.

The book is intended for a broad group of specialists involved in designing, producing and using analog-digital converters with IS [integrated circuits] in various digital data processing systems.

174 figures, 14 tables, 230 bibliographic references.

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ATS [AUTOMATIC TELEPHONE EXCHANGE] SOFTWARE

Moscow PROGRAMMNOYE OBESPECHENIYE ATS in Russian 1981 (signed to press 12 Oct 80)
pp 2, 5-8, 176

[Annotation, introduction and table of contents from book "ATS Software" by
Viktor Osipovich Ignat'yev, Boris Yevgen'yevich Alekseyev and Valeriy
Vyacheslavovich Rossikov, Izdatel'stvo "Radio i svyaz'", 7,000 copies, 176 pages]

[Text]

Annotation

Software requirements for ATS [automatic telephone exchange] are examined, and the composition, purpose and design principles of its component parts are defined and described. The working algorithms for the basic program and the methods and means for solving the problems which arise in the development, testing, production and operation of ATS software are given.

The book is intended for engineering and technical workers involved in the creation and operation of modern switching equipment.

Introduction

The creation and development of a nationwide automatically switched telephone network requires a significant increase in the number of automatic telephone switching centers (KU) which switch channels, subscriber and trunk lines, as well as perfection of their design and operating principles which ensure a substantial improvement in the tactical-technical, technical-economic and operating characteristics of KU and of the communications network as a whole. One of the most important areas for this perfection of KU, based on the achievements of modern electronics and computer technology, is the widespread use of stored-program control of KU operation.

Stored-program control is implemented in KU by a special-purpose computer which executes assigned functions under the control of programs stored in memory (ZU). The special-purpose computers used to control KU operations are called electronic controllers (EUM) in switching practice. More than 10 years' practical experience with EUM-controlled KU has demonstrated a number of substantial advantages of these KU over other types of KU in the area of operation, installation and production.

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One of the main advantages of the stored-program method of controlling KU which is implemented by EUM is the great functional flexibility of the KU in terms of changing and supplementing the KU operating algorithms when new requirements arise on the part of subscribers, operating personnel and communications administration. In KU which use control units with built-in logic, where the operating algorithm of a module is determined by the circuit design of the individual assemblies in these devices and the manner in which they are connected, the introduction of functional changes and additions is associated with substantial expenditures for redesigning and refabricating the assemblies which implement the corresponding functions and changing the wiring connections between assemblies. The additional expenditures just for redesigning this type of KU often exceed the initial development cost. For example, the initial development of the Crossbar No 5 coordinate ATS took 335 man-years, while 1900 man-years were spent on various functional changes and additions after this type of exchange was put into operation [4]. In stored-program KU functional changes and additions are made by changing and reentering programs in the EUM ZU; the KU equipment itself is not usually touched. Here the expenditures for making needed changes are approximately 10 times less than those for a coordinate system KU [5].

Contemporary systems requirements for KU are also directed toward more complete satisfaction of communications user (subscriber) requirements for new services and capabilities, which are growing rapidly, reflecting the growth in complexity and dynamism of the social and economic activity of people. The introduction of many of the services and capabilities required by subscribers has been delayed by technical and economic difficulties of implementing them in hardware KU. Operating experience with the first stored-program KU has indicated the presence and rapid growth in these requirements, and the possibility of satisfying them economically by means of special programs. For example, in the quasi-electronic ATS YeSS No 1, the selection of available services and capabilities has grown fivefold since it was first put into operation [4], and by the end of 1975 over 1 million subscribers of this type of ATS were using such services as speed calling, call waiting, conference calling, call forwarding, and others [6].

One significant advantage of KU controlled by EUM over other types of KU is the significant reduction in operational expenditures for maintaining switching center equipment and conducting operations associated with installing and removing subscriber sets, changing subscriber categories and the services they use, introducing new routing and changing the number of channels or links on individual routes.

Operating expenses are reduced in these cases to a significant degree due to the wide use of programs for testing the serviceability of equipment and locating malfunctions, and representing subscriber and exchange characteristics and connections in EUM memory in special tables with program correction of their content when changes must be made. The use of programs in the operation of KU reduces repair time, makes it possible to use less qualified operating personnel and reduces the amount of work done on remaking internal exchange connections. Since most of the actions of personnel in operating stored-program KU consist of interacting with existing programs, many of the functions connected with operation can be executed remotely. This makes it possible to organize centralized operation

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of several such KU from a single center and to use operating personnel more effectively, which also provides a significant savings in operating expenditures. On the whole, the amount of labor required to operate a stored-program KU may be approximately half that required for other types of KU [6, 7].

With stored-program KU, the administration of communication centers and networks has broad capabilities for objective accounting, monitoring and evaluation of the activity of switching center operating personnel, for improving operational processes and increasing the efficiency of utilization of KU, channel and communications lines equipment. These capabilities are provided by the availability at the KU of various programs for gathering statistical data on parameters and traffic distribution, the load on various types of equipment, the number and types of malfunctions, etc.

An important advantage of stored-program control of KU which takes on particular importance under conditions of rapidly developing communications networks is the capability of using separate data channels which serve as common signaling channels (OKS) for exchanging interaction and control signals among the KU in a network digital form, and implementation of dynamic network control.

The use of OKS makes it possible to simplify significantly the multiple sets of incoming and outgoing channels and trunk lines at a center, to eliminate from the equipment at a center a significant number of devices associated with receiving and transmitting interaction and control signals, and to increase the reliability and speed with which signals are exchanged; it also makes it easier to implement dynamic network control [8]. Due to the dynamic network control which is implemented by means of EUM and OKS, the efficiency of utilization of the switching equipment, channels and communications lines is increased and the quality of servicing of telephone calls is improved. For example, for an urban telephone network the introduction of dynamic control makes it possible to achieve savings of up to 30% of trunk lines and to increase call servicing quality by a factor of 1.5 or more [9].

Stored-program switching centers have significant advantages over other types of KU both in operation and in production and KU equipment installation.

The use of EUM as KU controllers makes it possible, through program implementation of complex logical functions, to simplify and standardize both the switching and control equipment at switching centers. For example, in the EUM-controlled quasi-electronic D-10 ATS there are 3.5 times fewer different types of assemblies than in an analogous coordinate ATS [5]. The same type of EUM can be used in KU of different types and purpose: quasi-electronic and electronic, urban and long-distance, terminal and center. Because of these circumstances, the organization and production process are simplified significantly, and the labor consumption and cost of manufacturing KU equipment are reduced. For example, the amount of labor required to manufacture an EUM-controlled KU is between three and four times less per number (per line) than the amount of labor required to manufacture the equipment for an analogous KU in a coordinate system.

The use of stored-program control of KU operation makes it possible, by entering special programs into EUM memory, to use the latter to automate testing of

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switching equipment and KU testing as a whole on site. The capability of using the EUM as standard testing equipment reduces substantially the amount of service equipment required to install KU, as well as the time required to install and put KU into operation [10].

Of course, the realization of these advantages of stored-program KU requires the solution of many complex problems associated with the development, production and operation of the new types of assets which provide these advantages--EUM programs.

This group of problems is so large that it is impossible to examine any of them in any detail within a single small book. Therefore, the remaining chapters of the present book are devoted to examining only the basic problems which are of greatest interest at the present stage of switching practice in our country. The authors have included among these problems those of choosing the composition, design principles and operating algorithms of the basic types of programs, and ensuring efficiency in their development, organization of their production and their operation.

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GAS-DISCHARGE MATRIX DISPLAY PANELS

Moscow ELEMENTY RADIOELEKTRONNOY APPARATURY, VYPUSK 41: GAZORAZRYADNYYE MATRICHNYYE INDIKATORNYYE PANELI in Russian 1980 (signed to press 17 Oct 80) pp 3-4, 73

[Introduction and table of contents from book "Elements of Radioelectronic Equipment, No 41: Gas-Discharge Matrix Display Panels", by Oleg Petrovich Yakimov, Izdatel'stvo "Sovetskoye radio", 20,000 copies, 73 pages]

[Text] Introduction

Intensive development of measuring techniques, computers, television, and control systems led to the necessity of processing and visual presentation of considerable amounts of information. It became necessary to create highly effective devices for displaying information. The most important components of such devices are indicators: devices transforming electrical signals into light signals.

In the conventional measuring instruments and devices, as well as in control panels, relatively simple display devices are used which show figures, letters, and various symbols. Considerably more complex problems are performed by indicators in the displays of electronic computers, where it is necessary to display a larger number of various symbols and graphs determined by thousands of units and ensuring communication between the screen of the computer and operator. Even more complex tasks are expected of indicators in television, radar, and automatic control systems (ASU), where it is necessary to have half-tone or even color pictures with a very large number of scanning elements.

Until recently, the only type of electronic indicators satisfying the requirements of displaying considerable files of information with complex coding was the cathode-ray tube (CRT). The following are the advantages of this type of indicators: universality, high light output, simplicity of information input. At the same time, almost all types of CRT have the following disadvantages: nonflat design of the screen, high operating voltages, hot cathode, awkwardness of the entire device due to the presence of high-voltage sources and filament circuit supply sources, and, finally, a relatively low level of reliability. The above-mentioned disadvantages make CRT definitely incompatible with modern integrated electronics. Therefore, in recent years, new kinds of screen-type display devices have been developed where the defects characteristic of CRT have been partially or completely eliminated.

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The screen-type indicators competing with CRT include: electroluminescent, gas-discharge panels, liquid-crystal, electrochromic and electrophoretic indicators. Since 1964, integrated-type gas-discharge display devices -- gas-discharge display panels (GIP) -- have been used most widely abroad. They have a number of important advantages over the above-mentioned screen-type indicators, and information display devices using GIP perform effectively the following functions: conversion of information from the electrical form to the light form, addressing information to the cells of the indicator, information storage.

According to the data of sources published abroad [10, 11], the most preferred areas of GIP application are:

- alphanumeric display boards for individual use with a relatively small information capacity;
- terminal screens for individual use intended for presenting alphanumeric information and having an average information capacity;
- large screens for collective use, including screens reproducing color images;
- television screens with a large number of brightness gradations.

Alphanumeric screens using GIP are used in output devices of complex measuring circuits, as well as control circuits for displaying values being measured, movement parameters of objects, transmitted commands, and other operating technical information. Screens for collective use are used widely in display devices of the output information of computers at large control stations and in command complexes. In conclusion, it should be mentioned that the service life of GIP is tens of thousands of hours.

The author is grateful to Candidate of Technical Sciences A. B. Pokryvaylo, who read the first version of the manuscript and made a number of useful suggestions, and also provided the author with some materials which he used in writing this pamphlet.

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PARAMETRIC RELIABILITY OF HYDROACOUSTIC ANTENNAS

Leningrad PARAMETRICHESKAYA NADEZHNOST' GIDROAKUSTICHESKIKH ANTENN in Russian 1980
(signed to press 5 Nov 80) pp 2-4, 190-191

[Annotation, foreword and table of contents from book "Parametric Reliability of Hydroacoustic Antennas", by Vladislav Borisovich Zhukov and Dmitriy Borisovich Ostrovskiy, Izdatel'stvo "Sudostroyeniye", 1800 copies, 192 pages]

[Text] The book presents problems of reliability of the parameters of multielement hydroacoustic antennas. Calculation methods are based on the statistical theory. Failure criteria are given by the directional characteristic, displacement of the extremums, width of the main maximum, and the concentration coefficient. The probability of failure-free operation is defined as a function of statistical moments of the spread of parameters and failures of the elements, as well as of the nonuniformity of the medium.

Problems of reliability are solved by direct and inverse methods. The failure criteria of the antenna is used to determine the permissible spread of the parameters of the elements during the stage of development, and it is possible to predict the operation of the antenna during the period of its operation.

Examples are given to illustrate the methods of calculating reliability in typical antenna problems with the use of the obtained results.

The book is intended for those engaged in the development of hydroacoustic equipment and specialists in its operation.

Foreword

The antenna is a terminal device of hydroacoustic stations which is directly connected with the medium in which energy propagates. The efficiency of an antenna and the preservation of its characteristics within the required limits determine the effectiveness of the operation of the entire station.

The general problem of the calculation of the reliability of an antenna can be divided into two problems: 1) determination of reliability during the stage of designing and manufacturing; 2) calculation of reliability in the process of operation. Reliability calculation is usually connected with the number of failures of the elements. Multielement antennas are characterized by the fact that, in some instances,

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the antenna can maintain its serviceability with one or several failed elements, while in other instances it may not meet the requirements even if there are no failures of its elements. When evaluating the reliability of an antenna it is practical to proceed from the necessity of ensuring the permissible output characteristics prescribed for the antenna.

The traditional methods of computing antennas presuppose that they consist of identical elements, and the amplitude-phase distribution of the oscillatory speed of the elements and the configuration of the aperture are determined by the nominal values of the parameters of the elements, and design and processing schemes. In reality, the characteristics of manufactured antennas, as a rule, differ from their design characteristics. First of all, it is caused by the fact that the elements of an antenna are manufactured with certain allowances, which, in turn, leads to the distortion of the directional characteristic and other output parameters of antennas. Thus, when computing the reliability of antennas, it is necessary to consider not only the total failure of the elements, but, chiefly, the spread of their parameters, which is the main problem which the designers of antenna systems have to solve. The operation of an antenna under real conditions is connected also with the appearance of errors caused by the nonuniformity of the medium in space and instability of its properties in time.

At the present time, the problems of the reliability of antennas are given more and more attention in connection with the increased requirements imposed on the allowances for the parameters of antennas, the necessity of multiple reproducibility, and the requirements for the stability of the characteristics in time during operation. There are also some difficulties in setting up a sufficiently representative experiment in which it would be possible to simulate the designs of multi-element antennas or test their reliability.

A natural method which makes it possible to consider an accidental spread of the parameters of the elements and their failures is the statistical method. The characteristics of antennas obtained in this case do not determine the concrete antenna, but determine its statistical characteristics describing all of the antennas of that type. Such statistical characteristics include, first of all, the mean value, dispersion, and the distribution function.

Methods of calculating antenna reliability can be divided into direct and inverse. The direct methods make it possible to determine the reliability of an antenna by the known statistical characteristics of the elements with or without consideration for the fluctuations of the parameters of the medium. The inverse methods make it possible to determine statistical characteristics of the elements by a prescribed (permissible) changes of the output parameters of the antenna. The inverse problems are solved during early stages of antenna designing. At that time, proceeding from the permissible spread of the output parameters of an antenna operating at the station, it is possible to determine the requirements for elements and to design an optimally reliable antenna. The direct methods serve for evaluating the potentialities of the developed design.

There are few publications treating the reliability of antennas in the above aspect. Some of the results published in the books "Problems of the Statistical Theory of Antennas" by Ya. S. Shifrin and "Directivity of Hydroacoustic Antennas" by M. D.

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Smaryshev can be taken for partial evaluation of the reliability of multielement antennas. However, many problems remain unsolved. For example, the statistical descriptions of a number of antenna parameters are incomplete, since there are no expressions for the distribution functions and antenna parameters, errors in the installation of the elements in the antenna and failure of elements are not taken into consideration, and there is no necessary information on the determination of the initial data and the spread of the parameters of the elements.

The authors of this book give a method to the developer of multielement antennas which makes it possible to perform a sufficiently complete calculation of the reliability of antennas, predict its operation in time, and present substantiated requirements for the elements of the antenna. The authors use a signal position to give a full statistical description of the parameters characterizing the directional properties of the antenna. Much attention is given to the methods of reliability calculation, which makes it possible to solve both the antenna problems, and the related problems.

It is requested to send all critical remarks and suggestions to: 191065, Leningrad, ul. Gogolya, 8, Izdatel'stvo "Sudostroyeniye".

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RADAR METHODS OF EARTH STUDIES

Moscow RADIOLOKATSIONNYYE METODY ISSLEDOVANIYA ZEMLI in Russian 1980 (signed to press 12 Nov 80) pp2, 261-262

[Annotation and table of contents from book "Radar Methods of Earth Studies", by Yuriy Aleksandrovich Mel'nik, Sergey Georgiyevich Zubkovich, Vladimir Danilovich Stepanenko, Yuriy Pavlovich Sokolov, Vadim Aleksandrovich Gubin, Vladimir Yevgen'yevich Dulevich, Sergey Vladimirovich Pereslegin, Aleksandr Afanas'yevich Veretyagin, Valentin Mikhaylovich Glushkov, and Yuriy Alekseyevich Yurkov, Izdatel'stvo "Sovetskoye radio", 3500 copies, 264 pages]

[Text] The authors present the principles of radar studies of the earth. The book gives a detailed examination of reflection models and characteristics of radar signals of the dry land, water surfaces, and atmospheric formations. The authors used a single basis to describe the methods of constructing and substantiating the parameters of systems of active radiolocation and radiometry for the observation of the earth's surface and meteorological objects from aircraft and satellites. Methods are given for using active and passive radar means for cartography, geology, hydrology, studying the vegetative cover, oceanography, ice reconnaissance, and other geophysical studies.

The book is intended for specialists engaged in remote exploration of the earth for scientific and national economic purposes.

Tables -- 32, figures -- 162, bibliography -- 118 items.

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RADIOCOMMUNICATION CHANNELS FOR ASU TP

Moscow KANALY RADIOSVYAZI ASU TP in Russian 1980 pp 1-2

[Table of contents from book "Radiocommunication Channels for the Automatic Control System of Transformer Substations", by A. A. Goryachev, Izdatel'stvo "Svyaz'"]

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RADIO COMMUNICATION EQUIPMENT OF AIRPORTS

Moscow RADIOSVYAZNOYE OBOURODOVANIYE AEROPORTOV in Russian 1975 (signed to press 12 Feb 75) pp 2, 213-214

[Annotation and table of contents from book "Radio Communication Equipment of Airports", by Aleksandr Fedorovich Logachev, Izdatel'stvo "Transport", 8000 copies, 216 pages]

[Text] This book describes functional circuits and basic circuits of UKV [ultra short-wave] radio stations R-824M, R-822, R-809M, shortwave radio station R-820M, transmitter R-647, and the radio receiver "Volna-K" which are used widely in civil aviation for ground and aerial aircraft radio communication.

The book is intended as a textbook for students of regular and correspondence departments of schools of special services of the Ministry of Civil Aviation of the USSR. It can also be used by students of higher educational institutions and by engineers and technicians of the communication services of airports.

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RELIABILITY AND TESTING OF RADIO PARTS AND COMPONENTS

Moscow NADEZHNOT' I ISPYTANIYA RADIOETALEY I RADIOKOMPONENTOV in Russian 1981
(signed to press 4 Dec 80) pp 2-5, 269-72

[Annotation, introduction and table of contents from book "Reliability and Testing of Radio Parts and Components", by Nikolay Aleksandrovich Mitreykin and Arkadiy Ivanovich Ozerskiy, Izdatel'stvo "Radio i svyaz", 30,000 copies, 272 pages]

[Text] This textbook presents the fundamentals of the theory of reliability, testing, and standardization of radio parts and radio components.

This textbook is intended for students of technical schools specializing in instrument-making; it can also be useful to engineers and technicians engaged in the problems of reliability and testing of radio parts and components.

Introduction

It is impossible to accomplish the far-reaching goals of creating the material and technical base of communism in the USSR without a wide use of radioelectronic devices. At the present time, there is practically no area of science and technology where radioelectronic equipment (REA) is not used.

It was noted at the 25th CPSU Congress that one of the main problems of modern development was and still is the acceleration of the scientific and technical progress. Scientific and technical progress is inseparably linked with a wide introduction of REA into all sectors of the national economy of the country.

Radioelectronic devices consist of a large number of elements performing various functions. Some elements perform only mechanical functions, such as fastening (screws and nuts, clamps, clips, pins) or translation of motion (gear drive, worm-gear drive, clutch). Some other parts perform electrical functions. These are resistors, capacitors, semiconductor instruments. Some perform simultaneously both electrical and mechanical functions. For example, these are plug and socket units, connecting plates, mounting bays, switches.

This textbook examines elements forming electrical circuits of REA. It is customary to call elements of electrical circuits radio parts, and radio components.

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A radio part is an element of an electrical circuit intended for its construction which has a complete structural form and performs simple electrical functions (increasing the resistance to the flowing current, accumulation of a charge, concentration of electromagnetic energy, etc). A radio part cannot amplify, generate, and transform radio signals.

REA use a large number of radio parts which are a structural element base of radio-electronics. Such radio parts are often called radio components. They include: installation items (control handles, fuse holders, plugs, etc); switching items (switches, buttons, etc); connecting items (plug and socket units, connecting plates, mounting bays, etc); transformers, choke coils, inductance coils, etc.

Almost all radio parts and components are assembled units, because they are assembled from individual parts connected at the manufacturing enterprise by assembling operations (screwing, riveting, welding, soldering, pressing, lamination, gluing, etc). Radio parts and components are constituent parts of any radio engineering device, therefore, it is customary to call them constituent items.

Modern REA is used under various conditions and must satisfy the following most important requirements: operate normally under prescribed conditions, be highly reliable, require a minimum volume of adjustment and development work, have interchangeable radio parts and components, etc. However, it is not always possible to satisfy such requirements completely. One of the causes of this situation is the difficulty of manufacturing radio parts and components of high stability and reliability. In this respect, large-scale standardization of radio parts and components is very helpful to the manufacturer and operating personnel.

Radio parts and components, just as any products of all sectors of industry, are covered by the state standards of the USSR, standards of the industry, or standards of manufacturing enterprises. The purpose of standardization is to produce articles which are effective technically and economically, have a prescribed degree of reliability, and are safe in operation. The following goal was set by the 25th Party Congress: "To enhance the role of standards in the acceleration of the scientific and technological progress and to improve the quality of finished products, raw and other materials, and constituent articles. To improve standards and specifications, and to enhance the responsibility of economic organizations, enterprises, and associations for their observance. To strengthen the technical control service". Great possibilities for improving the quality of REA are offered by the use of standardized functional assemblies and microelements formed into modules, micromodules and integrated circuits, which makes it possible to reduce considerably the dimensions, weight and cost of REA and to increase sharply its reliability, the level of mechanization and automation of production.

Radio parts and components and the articles made from them are subjected to various tests: acceptance tests, periodic tests, standard tests and reliability tests. The purpose of tests is the quality control of products, determination of possible use of the item under prescribed operating conditions, and determination of unified requirements for articles intended for operation under various operating conditions. The above tests are done in accordance with the normative technical documentation (NTD) for articles of specific types. Fulfillment of the requirements of such documentation by the enterprises of the radioelectronic industry makes it possible to produce high-quality radio parts and components.

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STATISTICAL ANALYSIS OF MULTIPLE-LEVEL PULSE TRAINS

Moscow VEROYATNOSTNYY ANALIZ MNOGOUROVNEVYKH SIGNALOV in Russian 1980 (signed to press 4 Nov 80) pp 2, 148

[Annotation and table of contents from book "Probability Analysis of Multiple-Level Signals" by Lyubov' Markovna Polyak, Izdatel'stvo "Svyaz'", 3800 copies, 148 pages]

[Text] The book is devoted to a systematic presentation of the theoretical foundations of probability analysis of multiple-level sequences which are widely propagated for transmission of digital and analog signals along communication lines. Underlying the analysis is a presentation of a linear multiple-level signal in the form of a uniform Markov chain with limited number of states.

The form of matrices of transitional probabilities characterizing the basic features of a multiple-level signal of some type is explained.

It is proven that primitive stochastic matrices of transitional probabilities correspond to a non-block multiple-level sequences, and nonprimitive stochastic matrices, whose ~~nonprimitiveness~~ index equals the desired volume of the block, correspond to block sequences.

Mathematical operations on matrices of transitional probabilities are considered, the result of whose application is used to determine the energy spectra of multiple-level signals. The aspects of continuous and discrete components of energy spectra of non-block and block sequences are discovered. Conditions in which a discrete component is absent from the spectrum of a transmitted signal are formulated.

Operations are described to obtain energyspectra of multiple-level sequences passing through specific linear and non-linear elements in the channel of digital communications systems. The result is an assessment of the effect of distortions of pulse amplitudes of a multiple-level signal on its energy spectrum; energy spectra of multiple-level sequences passing through a full-wave rectifier are determined; and several other linear and non-linear elements of the digital channel are defined.

Attention is focused on the study of the distributive functions of processes which occur in linear channels of digital communications systems. The probability density of the magnitude of intersymbol transitions is defined and the aspects of integral functions of the probability distribution of such processes as the detection of a unit interruption of a symbol in the line and a repetition of combinations of symbols with preset levels are determined. Methods are proposed for studying the integral functions of the probability distribution of the envelope of the process at the output of a filter-discriminator of clock pulses in a recovery circuit of time intervals of a regenerator with autosynchronization.

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The theoretical assumptions are illustrated with examples of probability analysis of various types of signals.

The cited methods of probability analysis obviate the need for approximate solutions associated with complicated evaluations of the degree of approximation.

For science workers specializing in electrical communications.

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TRANSMISSION OF DIGITAL INFORMATION VIA LOW SPEED CHANNELS OF COMMUNICATION

Moscow PEREDACHA DISKRETRNOY INFORMATSII PO NIZKOSKOROSTNYM KANALAM SVYAZI in Russian
1980 pp 1, 126-127

[Table of contents from book "Transmission of Digital Information Via Low Speed
Channels of Communication", by M. N. Aripov, Izdatel'stvo "Svyaz'"]

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